User Centered Design of a Learning Object Repository

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Abstract. This work outlines the design process of a user centered learning object repository. A repository should foster the development and acquisition of both generic and specific informational competencies. The results of the first stage of the user centered design process are presented which provide a clear understanding of user and task requirements and the context of use. A user study was conducted using quantitative and qualitative methodologies. A qualitative approach was performed through the content analysis of 24 in-depth interviews achieved through a random stratified sampling method. Regarding the quantitative approach, more than 5 million student navigation sessions were processed in order to know the real information behavior accomplished in the virtual campus and more specifically all the services and resources used and the search actions carried out by users. Our aim is to achieve a thorough informational behavior analysis that involves access, treatment, integration, evaluation, creation and communication of information for learning purposes which will be useful for integrating learning object repositories in virtual learning environments.

Keywords: Learning Object Repository (LOR), user centered design, log analysis, content analysis, e-learning, information-related competencies.

1 Introduction

Learning object repositories are becoming a common tool for organizing educational content, that is, all the resources used in a learning process. The main aims of a repository are, firstly, to assure access to content and its conservation and, secondly, to promote a high degree of reusability of the available resources. But learning is much more than just contents, and there is a real need to integrate the use of learning object repositories (LOR) as part of the learning process so that students take advantage of the new possibilities it offers. Using the learning object repository should be in itself a true learning experience.

Furthermore, the new European Higher Education Area (EHEA) promotes the design of learner-centered processes that focus on the acquisition and development of competences rather than on the consumption of contents. One of the goals of the EHEA framework is to 'create' professionals with appropriate skills that help them to manage in the current information society. Thus, informational-related competencies become crucial. Learning object repositories are therefore one of the most important

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elements of any e-learning system and the repository interface must be designed keeping in mind that real usage must be captured in order to provide instructors with data that describes the interaction between learners and the repository, thus the abovementioned learning experience can be measured to some extent. The integration of the learning object repository as part of the virtual learning environment will not be complete unless a user-centered design approach is taken on board. This paper is organized as follows: Section 2 describes learning object repositories and their integration in e-learning systems. Section 3 describes the definition of a user-centered design project to build a learning object repository. Section 4 presents the first stage of such a project; the research of the user in the context of a virtual learning environment. Finally, the conclusions drawn from this work and future research lines are summarized in Section 5.

2 Learning Object Repositories

With the creation of the new European Higher Education Area (EHEA) [1] and for a better alignment of learning with the requirements of the knowledge society, the education sector needs a new model of learning [2]. In order to do so, teachers must change their role from dispensers of knowledge to facilitators of individual and collaborative learning and knowledge development. This means a transition from an educational model based on established information channels to a new model where there are diverse channels [3]. Textbooks, workbooks, lectures and other pre-digested information from lectures must bring about a learning process based on information resources available in the real world [4]. Students should be encouraged to select resources from the Net, use/reuse and share them with the rest of the academic community.

A Learning Object Repository (LOR) is a basic service that provides learners with the contents they need according to the learning context in any moment of the learning process [5]. Besides, it helps teachers and instructors to better manage all the available resources and to understand the real usage of these resources by learners. Furthermore, there is a huge generation of selected or created resources in each semester, therefore the LOR becomes the right tool for managing all these contents.

In addition, the academic community is acting as a curator of the quality of the chosen/created learning objects, as teachers and students are putting into practice the appropriate information competencies. In this sense, learning object repositories are perceived as an essential tool for such a collaborative learning approach. On the other hand, learners must have some basic skills for accessing the repository and the interaction with it should increase their informational skills. The basic operations related to a learning object repository (from the learner's point of view) are information searching, browsing and retrieval. Users should be empowered to have the right information, at the right time, in the right format, with the optimal quality to meet a specific information need that fulfils a learning goal.

As stated in [6], the learning repository is in itself not enough to ensure a successful learning experience. It is necessary to build a true learning community around the learning object repository, with the aim of maintaining a continuous process of creating, sharing and reusing educational resources. In a formal learning scenario, such as

that defined by the new EHEA paradigm, the learning object repository cannot be just another technological service provided by the virtual learning environment, as it will be probably ignored by most of its potential users, mainly learners. Preliminary experiments [7] show that learners tend to minimize their interaction with static resources as they can be downloaded once and used locally many times. Therefore, it is important to integrate the learning object repository as an active element of the learning environment, promoting its use among learners. In order to do so, we propose to adopt a user-centered design approach, analyzing the real context where the learning object repository has to be integrated and taking into account the real user requirements from a methodological point of view.

3 User Centered Design of a Learning Object Repository

This work is part of a large project that takes place in a higher education institution, the Open University of Catalonia (UOC), with the aim of promoting the development and acquisition of competencies through the use of learning object repositories. The UOC is a purely online university that is currently evolving towards the EHEA. It has more than 40,000 students and more than 2,500 staff including instructional designers, teachers, tutors, academic and technical staff. The UOC uses a virtual campus as an integrated e-learning environment that allows students to pursue their studies purely online. We intend to design and develop a LOR that is not only useful as a mere repository but, at the same time, its use becomes an active element of the learning process, so students using the repository will achieve a set of competences.

The university established a set of organizational requirements mainly related with its technological architecture and also related with the e-learning methodological model. The second set of requirements is user defined and will be obtained through the user research described later on.

The current technological infrastructure is based on DSpace, which is already in use at the institution for publishing research results. This is the typical use of such technology, although DSpace [8] is intended to be used for storing and managing learning resources, that is, to be the core of the institutional learning object repository. One of the main drawbacks of DSpace is its user interface, which needs to be completely redesigned in order to be really usable. The default user interface reproduces the internal structure based on communities, sub-communities and collections, where each item in a collection is identified by its author, its title or its keywords. Although this may be sufficient for most typical uses, nevertheless, in the case of educational resources it is not so clear. For example, exercises do not have a clear title. On the other hand, some resources are created collaboratively during the academic semester, so the figure of the author is not clear. Therefore, we need to redefine the key elements that will be used for browsing the learning object repository, according to the desired learning goals.

As our intention is that the learning object repository is a true learning experience, its main goal cannot be just providing learners with searching and browsing capabilities. Quite the opposite, learners are expected to develop informational competences while they use the learning object repository, together with the acquisition and development of competences related to the repository thematic subject (if any, i.e. Statistics). In order to do so, we will redefine in full the user interface in order to provide a

comprehensive browsing experience, which will help learners to establish a relationship between resources, topics, keywords, competences and so. In this sense, it is worth remarking the MACE project [9], which aims to provide new user interfaces for browsing. We intend to extend the capabilities of the MACE project search engine in order to accommodate the new requirements imposed by the EHEA paradigm. Furthermore, we also intend that the virtual learning environment gathers and analyzes real usage data, in order to provide learners with not only a more improved personalized system but also teachers and managers with a better understanding of the learning process built around a learning object repository.

3.1 UCD to e-Learning

Taking into account all these elements, we decided to plan and develop this project applying user-centered design (UCD) [10]. The UCD is both a design philosophy and a product development process. This discipline places the user at the center of all the process, taking into account their characteristics, needs and wishes. As a mode of philosophy, the UCD is based on the principle that a key element for the success of a product is its adaptation to the user. Adaptation is understood at different levels which include the adaptation to human characteristics and limitations, adaptation to users' needs and desires, adaptation to the context of use. A UCD product development process includes three main phases: gathering user requirements, designing the product iteratively and finally, evaluating the prototypes of each design iteration.

By applying a UCD process to the design of the LOR, we can ensure that the repository provides what it was initially conceived to provide and, at the same time, we hope to obtain important results on the Learner-Centered Design which is how the design should be done in order to guarantee a good learning experience. The project follows the principles of the ISO 13407 [11], namely the active involvement of users and a clear understanding of the user and task requirements, an appropriate allocation of functions between users and technology and the iteration of design solutions and multi-disciplinary design. This international standard describes four user-centered design activities:

1. Specification of the context of use: identify the users of the LOR and under what conditions they will use it.
2. Requirement specification: identify students' needs and goals and organizational requirements.
3. Creation and development of design solutions: these designs will take into account the information gathered in the two previous phases.
4. Design evaluation: designs are evaluated taking into account users, requirements and the context of use.

The following section presents the results of the first and second phases.

4 User Research and Specifications of the Context of Use

Keeping in mind the user context and the application needed, we have used a multiple methodology approach on the information behaviour. On the one hand, a qualitative

perspective through content analysis and discourse analytical methods, and on the other, a quantitative approach through log analysis and data mining. By combining both methodologies we get, the reasons why students develop an information behaviour profile and their real navigational behaviour which provides data without the bias as their actions were transparently recorded.

The virtual campus is an integrated e-learning environment which includes all the needed services and tools. The learning object repository is one of its elements. As the main users of the learning object repository, learners are the subject of the user research.

4.1 User Qualitative Research

The virtual campus becomes a common space where students develop information behaviour; that is to say, how they execute a set of activities, such as the identification of needs, the search for, use and transfer of information [12]. And it is in this learning environment where students acquire or are able to identify, find, evaluate, organise, communicate and use the information effectively, both for solving problems and for lifelong learning [13]. Therefore, in the research carried out, we approach students in order to describe their information behaviour and their information-related competencies in the academic context in order to improve the services used to access and use the information needed for achieving the learning goals.

In this study, 24 in-depth interviews were performed on mature e-learning students from a purely virtual university (UOC). Throughout course 2006-07, there were a total of 38,842 students enrolled in undergraduate programmes, where the average age was between 26 and 35 years (58%) and more than 68% of the total students had a full time job and 55% had children.

Keeping this typology of student in mind, a stratified random selection of a sample was made with segmentation according to categories on a series of variables. We distinguished three age groups: a group of 25-35 year olds which includes the student average age; a group of 35-45 year olds and finally a group of more than 45 year olds as this age is regarded as critical for the digital divide [14]. The population was segmented in terms of gender (female/male) which can be considered proportional as there are 51% male to 49% female. Afterwards, we segmented each stratification in two groups that we called “Novice” and “Advanced” students. “Novice” referred to those students that have only 1 or 2 semesters at the university; therefore they have some knowledge and skills of the virtual campus resources. On the other hand, we used “Advanced” for those who have been enrolled for 3 or more semesters which are supposed to be more information competent. Finally, we stratified the segmentations once again in two subgroups “Experts” and “Non-experts” in terms of Information-related competencies. “Experts” was used for students that we considered to be information competent and therefore fulfilled two conditions: the first one is that they had at least once searched and retrieved an electronic article from any of the subscribed databases of the digital library and secondly, they had at least once uploaded content on the Internet, i.e. videos, photos or created a weblog.

This stratification was not proportionate, in the sense that the number of samples in each category did not necessarily correspond to their relative size in the population.

This was not regarded as a problem once the goals of the stratification are justified by the objectives of the research [15].

The initial stratified sampling was designed through telephone interviews in order to hold the face-to-face meetings. Prior to the meeting, they received a small questionnaire by email about when was the last time they searched and used information for their several needs in their academic, workplace and daily-life environment. This step helped participants to get a previous idea of what the interview was about and provide the interviewers with an incident case to be explored during the interview in order to make participants remember past real information-seeking situations [16].

Finally, the structured interviews were performed; each of them lasting from 60 to 90 minutes, between September and October 2007, in Barcelona, Spain. These interviews were recorded by audio and video, with the permission of the participants. Afterwards, the interviews were transcribed in text form and used as the raw data for the content analysis method. Afterwards, all this data was human-codified with a software tool, NVIVO 7.0 [17]. We created a codebook with all variable measures which were established following the main actions that the information behaviour manifested: access, treatment, integration, evaluation, creation and communication [18].

4.2 User Quantitative Research

The goal of the quantitative research is to collect data about how the students use the e-learning system in everyday real situations. This usage data will be processed and analyzed to obtain new evidence about system usage and about student navigation. To do that, a three-level methodology of analysis has been used [19] focusing at the first level. Working at the first level, obtaining navigation paths, requires a complex system for managing and processing log files. To obtain patterns and other results typical data mining methods are used [20].

The data set used in the analysis belongs to the spring semester of course 2006-07. Throughout the semester, the log files have been gathered, filtered and have been stored to be able to be processed in order to obtain the student navigation paths. The first step of the analysis is to obtain all the navigation sessions of the students. Afterwards, these navigation paths or sessions will be analyzed with the goal to discover new information about student behavior and system usage.

The log files do not provide information rich enough to obtain relevant information about the student behavior in the system. Therefore, to be able to obtain the navigation behaviour of the users, we decided to introduce a set of embedded marks in the system [19]. These marks leave a clear track in the log files and can be processed later. To do that, a marking strategy has been designed obtaining a map of marks that have been embedded in the e-learning system.

The spring academic semester had a duration of 136 days, the first day being the 28th February and lasted until the dates of the publication of the final marks being the 12th and 13th of July. All students share the same virtual learning environment and also the key dates of the course. The number of students registered during this semester is 29,531. During the course, the log files from the active front-end servers of the virtual campus were received and pre-processed everyday. The log files, once pre-processed thus eliminating all that redundant, incomplete or superfluous information, occupy a disk space of more than 150 GB. From this point, these files have been

processed through an algorithm that allowed obtaining all the navigation sessions. These sessions have been stored in a unique file of a size of around 790 MB.

All the student navigational sessions obtained from processing the data set have been stored in one file where each line represents a single user navigation session in the virtual campus. This file contains 5,326,697 lines and, therefore, the total number of sessions of the semester. Studying carefully the data, it can be observed that there are some incomplete. We decided to eliminate them since they do not bring information about user navigation and probably were failed sessions. Once eliminated, the data set obtained contains 5,293,237 sessions which is more than 99% of the original file.

These navigation sessions are a very valuable information source that had never been obtained before. They show a lot of information about the users and how they use the virtual campus. Even so, it is interesting to continue processing and analyzing this data. As a matter of fact, these navigation paths represent the starting point of new analyses and studies about the virtual learning environment and its users.

5 Results

The analysis of the interview content and the log analysis showed two main student behavioral patterns. As a result of the qualitative analysis, one major interpretative repertoire of information behaviour appeared among mature e-learning students following the “googlizated behaviour” usually applied to teenagers [21]. Contrary to that, these students are not using the teenager’s tools but paper as a preferred format, Word software as a creation tool and e-mail as their communication tool.

From the log file analysis, we can draw what we called a "blackberrized behavior” in the sense that that students access to services and tools of the campus with the aim of getting updates. The common session of a student last 7 seconds and there are several sessions each day. This finding reinforces the idea that students do not use the virtual campus for studying but for communication purposes.

Some of the recurring expressions describing both patterns found have been organized from the codification performed through the following information actions:

a) Accessing to information:
Google is the search tool for all the interviewers: "when I have to search anything "I do" a Google, nowadays, it is the main source of information." The common opinion is that Google is the most complete source of information and that it retrieves information in a very fast way and that it is well structured and thematically ordered.

Related to accessing the virtual learning environment, the student behavior is very constant in the sense that we can conclude that during working days, the duration of the navigation session is short and the access is frequently. 7 seconds is the time one user needs to login, load the virtual campus’ home page, and make a glance to see if there are new messages. This value is important to be taken into account for interface design. If we want to capture the student’s attention in the home page, the system should be capable of generating and show useful information in less than 7 seconds. The distribution of the duration of the sessions shows that there is another operation a part from see the news and to go out, and it is the one where students carry out tasks in the virtual campus and, therefore, with a longer duration.

b) Treatment of information:
Generally, people for study purposes print their selected information sources or didactical materials. Paper was considered more secure, provided a feeling of more control, something more familiar, and something more convenient. But this feature was different among the ages of interviewers and their discipline. Navigation data showed that only a small group of students use the digital library as a study habit, reinforcing the fact of not studying online and on screen.

c) Evaluation:
In the academic context, students are provided with the necessary content to carry out the evaluation tasks. If they want more information, it is something complementary, but within the virtual classroom, they got the material provided by the most reliable source which for them was the teacher. Adding to that, the analysis of the virtual campus navigation sessions showed that there is no clear pattern. Students can be grouped in several navigation profiles because they behave differently depending on the moment of the day and on the moment of the course. Therefore, educational interfaces have to take into account behavior changes throughout the semester and also the information needs of each course.

d) Creation and Integration:
The main tool for creating and integrating information is Word software. Students mostly when generating a document for evaluation purposes recognize that "I copy and paste material that I found on the Internet and then I create the essay in this process on a Word file". So this way of cutting and pasting is the most universal and familiar method of study rather than reading and digesting. Furthermore, these text files are also used for storing bibliographic sources.

e) Communication:
In order to interact with other fellows and with teachers, email is the main channel. However, they like collaboration among students from their class but they hate the "forum" or "debate" tool provided in the classroom and they also dislike teamwork as they associate it to having to meet in a face-to-face manner. As mentioned, most of the students log in on the virtual campus several times each day only to check their mail.

6 Conclusions

This present study presents the work in progress of the integration of a learning object repository in a virtual learning environment from a user- centered design approach. Learning object repositories are becoming a key element in virtual learning environments as they provide the basic infrastructure for managing all the learning resources used during the learning process. Nevertheless, it is important to ensure that learners will use the learning object repository as expected, and that such interaction will be captured in order to be further analyzed.

Once the first stage of the user-centered design process is finished and the requirements are analyzed, it is then time to proceed with generating design solutions. In the particular case of a virtual learning environment and taking into account the user research, the learning object repository must be useful not only as a simple space

where learning resources are found, but as an active component providing learners with a true learning experience. Students are "googlized" and "blackberrized" and, therefore, the interface must allow them to use the repository taking into account their actual skills but should be formative enough to change their behavior and improve their skills. Obviously, this learning experience will be different depending on the nature of each subject, but some common requirements can be identified. We want the learning object repository to help learners to establish relationships between resources, in accordance with their similarities, overlapping and even user preferences. It is in this process of establishing relationships that the learner creates a mental map of the whole subject, thus improving his or her understanding of it. The browsing engine should avoid the use of Google-like search boxes and promote other interactive elements such as tag clouds and hierarchical taxonomies, among others.

Current and future research in this subject should include the development of a social layer with regard to the learning object repository, as part of its deeper integration within the learning process, in order to promote its continuous use, analyzing user behaviour in order to detect possible problems or improvements. On the other hand, as the number of learners accessing the virtual learning environment through mobile devices is increasing, hence, it is necessary to adapt some of the services provided by the learning object repository to this new learning scenario, taking into account mobility and accessibility issues. This is not only a technological issue, because the access device has different purposes depending on the context where is used. Finally, the adoption of semantic web techniques will enable better personalized services combining all the elements in the learning process, that is, users, contents and services. Personalization is one of the key aspects in providing learners with a true learning experience and which is perceived as being something real and useful.

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